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RESEARCH PAPER

Private Native Forestry in NSW: Environmentally Benign, Economically Important but Silviculturally Challenged?

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Abstract With large areas of public native forests now converted into National Parks and unavailable for timber harvest, private native forests (PNF) in New South Wales (NSW) are becoming increasingly important in providing timber for the wood processing industry. At the same time, there is increasing interest in the role that these private forests play in providing and maintaining habitat for wildlife. Historically, timber production from these forests has been opportunistic, with little or no silviculture to maintain wood production potential. Market circumstances and policy settings have not favoured sound silvicultural practice, generating an exploitative and short-term view of the timber resource to maximise short-term returns. This has occurred at a time when these forests are an important and increasing source of log supply to industry. This paper discusses payment of biodiversity credits (incentives) to improve both environmental management and timber production outcomes, and examines the findings of some recent studies on the 'sustainability' of PNF. Willingness-to-pay (WTP) and willingness-to-supply studies reveal a disparity between the demand and supply prices for biodiversity and habitat 'services' in many cases. Recent 'sustainability' studies indicate forestry operations are relatively benign in their impacts on biodiversity, compared to other land uses. However, in the absence of increased financial returns from PNF and in the face of increased public demand for greater environmental outcomes, there seems little alternative to meeting the competing demands of biodiversity and timber production than to implement a system of incentive payments which reward sound private forest management for a multiplicity of objectives.

Keywords Forestry incentives · Biodiversity credits · Willingness-to-pay · Flow-on effect · High-grading

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Introduction

This paper provides an overview of issues impacting upon private native forests (PNF) in New South Wales (NSW) and summarises some recent thinking and research on the concept of sustainability in these forests, with a particular emphasis on biodiversity issues. The economic factors driving silviculture in these private forests are outlined leading to a discussion of the potential for biodiversity credit payments to modify landholder management decisions in these forests, or at least be rewarded for the public goods (habitat provision) provided.

A significant proportion of the native forest resource in Australia, and in NSW in particular, occurs on private land (Table 1). Logs from PNF are now critical for supplying the hardwood native timber processing industry in NSW. However, it should be noted that much of the PNF estate is not suited to wood production and is not likely to be subjected to any commercial timber harvesting activity. For all intents and purposes, much of the PNF resource is effectively a de facto national park, being maintained by the landowner and providing public benefits in many ways.

During the late 1990s, the Regional Forest Agreement (RFA) process was implemented to 'enhance the conservation and sustainable management of Australia's native forests' (DAFF 2005). The RFAs on the east coast of NSW, and to a lesser extent the Western Assessment process in inland NSW, resulted in reductions in the harvestable area and log supply from the public forest estate as increasing areas of production forests were converted to national parks and reserves (Table 2).

Particularly, obvious in the post-RFA era is the increased reliance amongst north coast mills on private timber supplies. In northern inland NSW, most hardwood mills are small operations with log throughputs of less than 3,000 m^3 per annum and are entirely reliant on private timber sources. There is only one mill located in Walcha which relies heavily on the public resource though this mill is the largest in the region. Conversely, the remaining cypress mills have larger log throughputs and rely mostly on logs from public forests.

Table 1 Australian native forest cover

State	Area of private native forest (1,000 ha)	Private forest as a share of all native forest (%)
New South Wales	8,532	32
Queensland	10,213	18
Victoria	1,298	16
Tasmania	922	29
South Australia	822	7
Western Australia	1,639	6
Northern territory	1,511	47

Source: Private forests Tasmania (2005)

Table 2 Log supplies in selected NSW regions

Region	Forest type	Processor reliance on private timber in 2005	Change in public forest supply (pre-RFA to 2005)	Change in private forest supply (pre-RFA to 2005)
Upper and lower North East NSW	Hardwood species (mostly eucalypts)	66% of mills totally reliant 18% of mills >50% reliance 16% of mills <60% reliance	Reduction from 630,000[a] to 477,000[b] m^3 (includes part of Northern Inland supply)	Increase from 350,000[a] to 460,000[d] m^3 (includes part of Northern Inland supply)
Northern Inland NSW	Hardwood species	89% of mills totally reliant (represents 22% of logs processed) 11% of mills <5% reliance (represents 78% of logs processed		
Northern Inland NSW (Brigalow South and Nandewar)	White cypress pine	Four mills remaining post-Western Assessment decision, reliance up to 12%	Reduction from 78,000 to 40,000 m^3[c]	Varies up to 5,000 m^3

[a] CARE (1999a, b)

[b] Forests NSW (2005)

[c] Irvine R (personal communication)

[d] Northern Rivers PFDC (2005)

The reductions in log supply, along with associated industry 'assistance' (compensation) packages, have resulted in some processors leaving the industry and others restructuring their businesses to increase value-adding. By the end of December 2002, total assistance payments to the timber industry from Commonwealth and State Governments through the Forestry Industry Structural Adjustment Program (FISAP) totaled $112.3 M for NSW (BRS 2003). A further $47.4 M was made available by the Commonwealth Government in the 2003–04 financial year (Macdonald 2002).

In the Upper and Lower North East RFA regions of NSW, processors remaining in the industry have substituted private for public log supplies, as evidenced by the increased harvest from private property (Table 2). In addition, a recent survey of so-called 'Crown' sawmills in NSW which have an allocation of logs from the remaining public forest estate revealed that on average 20% of their log supply comes from private forests (Table 3).

Anecdotal evidence from forestry consultants suggests that the increased private forest harvest may have been driven by an impending PNF Code of Practice being developed within NSW Government. There is conjecture that concerns over the potential impact of the code on future timber access may have accelerated and

brought forward harvesting operations on private land with the objective of extracting timber prior to the introduction of tighter regulations (Cohen 2006). Until the new Code is implemented, PNF in NSW operates under an exemption to the *Native Vegetation Conservation Act 1997* (DLWC 1997).

The Contribution of Forestry to Regional Economies

In Australia, forestry typically has higher economic flow-on effects per hectare than alternative agricultural land uses, particularly where timber processing occurs in the same locality as the forest resource.[1]While the economic impact in terms of jobs, household income and value of gross output for native forestry in regional NSW is often below that of agriculture, the economic flow-on effects of forestry are often larger per unit of direct impact due to the labour-intensive nature of timber processing (Table 4). The information in this table includes mainly native forestry activity, but some plantation (exotic softwoods) activity in the Northern Statistical Division of NSW.

For native forestry alone, data collected during the North East RFAs (CARE 1999a, b) and the Western Assessment process (CARE 2002; CARE 2006b) reveal that:

- Every 1,000 m^3 of hardwood sawlogs processed generated $454,000 of gross output, $127,000 of household income and 5.07 jobs in 1997–98 and
- Every 1,000 m^3 of cypress pine sawlogs processed generated $707,000 of gross output, $158,000 of household income and 6.65 jobs in 2002.

These impacts include all direct and indirect effects, to provide a measure of the total economic impact of native forestry activity on those regional economies.[2]

Jay A (personal communication) estimated that the typical harvest from north coast native forests is 12–20 m^3/ha of sawlogs taken over a 15–20 year harvest cycle, often as a high-grading operation[3] (Combe et al. 1998). On an annual per hectare basis, these private forests therefore generate approximately 3.04–6.75 jobs per 1,000 ha of forest subject to selective harvesting. Jay A (personal communication) estimated that with a more intensive silvicultural regime, commercial yield could be tripled generating 9.12–20.25 jobs per 1,000 ha.

A study undertaken in the Kyogle area on the north coast of NSW in 1997 revealed that beef production generates 4.45 jobs per 1,000 ha (Thompson et al. 1997). Many beef cattle properties contain areas of commercial private forests, so

[1] A comparison of the economic impacts of agriculture and plantation forestry in the Oberon area of NSW has been reported by Powell and Chalmers (1993).

[2] Direct impacts measure the value of gross output, employment and household income attributable directly to activities in the native forestry sector including forestry, logging and sawmilling. Indirect impacts are the value of gross output, employment and household income in other sectors of the economy that either supply inputs to native forestry activities (known as the production induced effect) or in which native forestry activity derived wages are spent (known as the consumption induced effect).

[3] High grading refers to removal of commercial trees from the forest stand, but without thinning or culling of suppressed, defective or large non-commercial trees.

Table 3 Log supplies in selected NSW regions[a]

NSW supply region	Log supply from private land (m^3)	Log supply from public forests (m^3)	Private forests share (%)
Central	59,500	258,500	19
North east	46,500	127,500	27
Southern	5,650	87,850	6
Western	15,100	40,200	27
Total/average	126,750	514,050	20

[a] Only includes Crown mills which are mills with a public forest supply agreement

Source: Forests NSW, unpublished survey (2006)

Table 4 Economic features of forestry and agriculture in the northern statistical division of NSW (2001)

Sector and economic measure	Direct effect	Indirect effect	Total impacts	Type II ratio[a]
Agriculture[b]				
Gross output ($M)	2,381	1,862	4,243	1.782
Household income ($M)	590	420	1,010	1.713
Employment (no.)	17,107	14,739	31,846	1.862
Forestry[c]				
Gross output ($M)	72	52	124	1.718
Household income ($M)	10	10	20	2.035
Employment (no.)	346	376	722	2.087

Source: CARE (2006a)

[a] The type II ratio is the ratio of total impacts to direct impact. The higher the ratio, the higher the indirect or flow-on contribution to the total economic impact

[b] The impacts include production, transport, marketing and processing

[c] The impacts includes forestry activity, logging and sawmilling

timber and beef cattle production can operate simultaneously. Indeed, native forest thinning may provide additional grazing capacity as opening up the forest canopy stimulates pasture growth.

Silviculture in the Private Forest Resource in NSW

Unlike the situation in some European countries where native forests on private land are managed intensively and may generate up to a third of farm income (Brandl 2002), PNF in NSW are managed in a relatively *ad hoc* manner. A study of the economics of private native forestry on the Northern Tablelands on NSW reported these forests were typically subjected to timber harvest during times of relatively low cash flow from other farming activities (Thompson 1998). Lack of forest management skills amongst landholders combined with high thinning costs and low stumpage prices means that intensive silvicultural treatment is rare.

In private cypress pine forests, Thompson (1998) and Andrews (2003) reported thinning costs of up to $450/ha. Typical stumpage (log prices) for cypress averaged $33–52/m^3 in 2002 (NSW Cypress Industry 2003) and Thompson (1998) reported typical yields from private land of 5 m^3/ha, with a harvest interval of 30–70 years following an initial harvest and thinning treatment. This generates a return to the landholder in the range of $165–260/ha every 30–70 years. Using a real 5% discount rate, the net present value (NPV) of these combinations is consistently negative, indicating the investment in thinning is not financially worthwhile. Even where the thinning treatment doubles the commercial yield at subsequent harvest to 10 m^3/ha, the NPV remains negative. It appears that investment in cypress thinning on private land may only be financially attractive where it results in additional pasture production and grazing returns under the thinned trees. On some sites, there may also be additional environmental benefit through reduced soil erosion from improved groundcover (Thompson 1998; Andrews 2003).

Using discounted cash flow analyses combined with a forest growth simulation model (EUCAMIX), Jay (2006) found that financial returns for private eucalypt forests on the north coast of NSW were not conducive to intensive silvicultural management when any positive real discount rate was used.

Jay (2006) stated that low returns from intensive silviculture in these forests occur because of:

1. *Poor forest condition*. Much of the forest resource is in poor condition from past high-grading activity, hence costly silvicultural treatment (mostly culling) would be required.
2. *Lack of responsiveness to thinning*. The growth response from treatment is likely to be moderate on all but the highest quality sites.
3. *Long time for financial rewards*. Returns from improved commercial timber yields are not be realised until approximately 18 years post-treatment.

Moreover, a lack of landholder forestry knowledge and skills, combined with the sovereign risk associated with costly treatment in a climate of uncertainty about the rights for future harvest, has compounded landholder aversion to investing in restorative silviculture.

Jay (2006) modeled several variants of the proposed Code of Practice for NSW and concluded that the code may in fact exacerbate the problems arising from the present lack of silviculture. Draft versions of the code include prescriptive approaches which place arbitrary limits on basal area reductions and large tree removals. This may further encourage extraction of just the remaining commercial timber—a precautionary measure by private landholders inexperienced in forestry measurement techniques to ensure they remain within the extraction limits specified by the code.

Under the proposed code, approved PNF property development plans would remain valid for 15 years, while forest growth modeling reveals that thinning benefits occur from 18 years onwards. This adds to the sovereign risk, further deterring silvicultural treatments due to the risk that by the time the financial (growth) benefits from silviculture are realised, the plans and associated harvest rights may no longer be valid.

The present incentive situation in NSW generates an exploitative regime of 'high-grading', in which there is little silvicultural 'release' of the forest and competition for space, light and nutrients remains at a level which is not conducive for optimum forest growth. This combined with the retention of defective or low quality stems progressively reduces the future genetic and commercial potential of the forest. The result may be a substantial reduction in the productive capacity of the private forest resource and consequent supply reductions for native timber processors in the future. As noted by Raison et al. (2001), such a reduction in productive potential is contrary to the principles of ecologically sustainable forestry.

Biodiversity Credits for Private Forests?

A system which rewards landholders for the provision of a range of ecosystem services has been under discussion in Australia for some time (e.g. BRS 2005). The general concept is that in addition to receiving income from marketed goods (e.g. livestock, crops, timber), landholders receive payments for the forest non-market goods and services, including ecosystem services such as the water filtration, carbon sequestration, air filtration, climate amelioration, recreational services and biodiversity enhancement generated from native forests.

Jay (2006) suggested biodiversity credits as a mechanism for providing landholders with sufficient funds to invest in improved silvilcuture and overcome the problem of high-grading. This approach specifically acknowledges the temporal and dynamic aspects of timber production systems and postulates a system of sustainability debits and credits over time, which allows for an initial reduction in forest habitat attributes immediately following harvest or thinning operations, but the potential for these attributes to be restored or improved in the future due to silvicutural release and subsequent improved growth and vigour. The approach is premised on the restorative capacity or 'ecological resilience' of the forests, a feature that is frequently unrecognized and poorly understood, particularly by policy-makers. Any temporary reduction in habitat values resulting from harvesting or other silvicultural treatments must be within the restorative capacity of the forest.

Jay (2006) calculated the scores for a range of habitat sustainability metrics[4] which are currently used in Australia, across various forest management histories. It was not possible to determine whether the apparent small differences in score were due to forest structure *per se*, because there were only a four replicates per forest structure type. The scores for a given habitat value scoring method were not significantly different between the six silvicultural histories, even at a 25% significance level (Fig. 1). This finding suggests that private native forestry has minimal impact on the *general* biodiversity value of these forests, as predicted by the metrics tested. Moreover, the study also suggests that any type of forest cover will produce much higher habitat scores than predominantly cleared land.

[4] The term 'metric' is a generic description used by ecologists to describe various measures which have been devised to assess habitat quality. They usually involve a total score which is a mathematical combination of weighted individual habitat attribute scores.

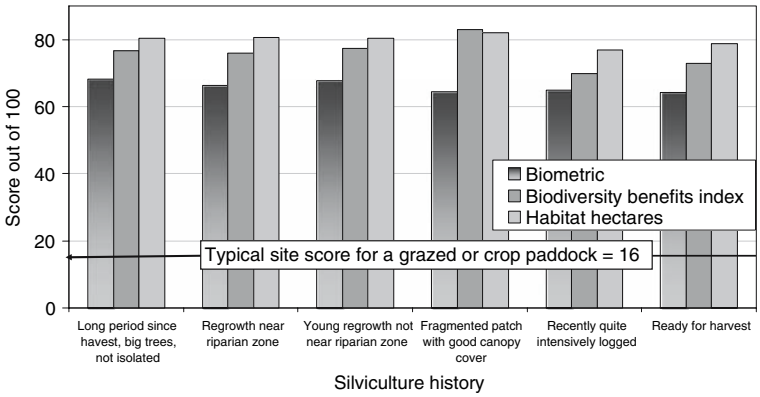

Fig. 1 Average habitat value site scores for northern NSW forest plots *Source*: Based on data from Jay A (personal communication) and Peacock (2006)

Similar findings occurred when the forest growth simulation model EUCAMIX was applied to a sample of northern NSW forest stands. Similar scores were obtained for general forest structural attributes associated with habitat and biodiversity across a range of silvilcultural treatments (not significantly different using a 25% significance level), which included high grading, intensive silvicultural intervention (tree culling), the use of the Australian Group Selection System (creating large gaps in the canopy, as described by Florence (1996)) and nil intervention.

The argument for the payment of biodiversity credits to stimulate improved silvilculture encounters an obstacle if conventional economic logic is applied to these findings. The findings suggest that *any* form of silviculture, even undesirable high-grading, preserves the *general* habitat values in these forests. Therefore, improved silviculture does not appear to be generating any additional biodiversity (or public) benefits for which the landholder might be rewarded, either from public funds or from private payments where these forests are used as offsets for habitat removal elsewhere.[5] Consequently, economic analysis might conclude that most benefit from improved silviculture is of a private nature via increased future timber yields and therefore any investment in silviculture is a matter for the forest owner or manager and not the target of biodiversity credits. However, the issue is not as straightforward as this logic would suggest and there are a number of reasons for considering the use of incentives to promote improved silviculture in private forests, as outlined below.

Regulation May Generate Perverse Outcomes

Economic analysis of a proposed Code of Practice for NSW carried out by Jay (2006) indicates negligible environmental gains, but a strong potential for loss of income by landowners. The impact of the code on landholder willingness to

[5] As noted in DEC (2006), a BioBanking scheme has been suggested for NSW where developers whose actions reduce biodiversity in one location can purchase biodiversity credits in another location to offset the loss.

improve future forest productivity through silvicultural treatments, such as culling, is also postulated to be negative.

One of the primary obstacles to increased forest productivity in the draft code is the need to retain large trees (which often develop hollows) for habitat purposes. Retention of large trees (with the view to maintaining biodiversity values, a public benefit) can lead to suppression of growing stock and reduced future value of timber production, i.e. a reduction in private benefits. The habitat tree requirement, while aimed at correcting one perceived market failure (namely loss of habitat in PNF[6]), generates another market failure in terms of lost commercial value. This problem arises from the undeclared intent of the code to attempt to protect and maintain all habitat values in all parts of the forest at all times. It is unclear what the forest is being protected from, because the restorative capacity of the forest or its 'ecological resilience' has been clearly demonstrated.[7]

If silviculture is taken to the point where commercial timber production is maximised, very few large trees might remain. So there is an argument to use financial mechanisms to offset lost forest productivity by retaining some large trees, promoting some silvicultural improvement, and at the same time avoiding the extremes of either 'locking up' these forests from any productive use or the current exploitative regime of high-grading which regulation appears to perpetuate. In essence, the issue is one of achieving multiple outcomes (biodiversity conservation and timber production) in private forests, but acknowledging the private financial motivations that will drive the process and finding a system which delivers a mix of public and private benefits, without imposing a net cost on society (i.e. where total cost exceeds total benefits).

General Versus Specific Habitat Measures

A criticism leveled at general habitat metrics—including those examined by Jay (2006), Peacock (2006) and Vaughan et al. (2006)—is that a total score does not cater for the impacts of forestry on specific habitat niches and species of local importance, e.g. Kavanagh (2003) and Lindenmayer (2006). Rather than using a 'one-size-fits-all' regulatory approach for PNF, each operation could be considered on its individual merits and within the context of the surrounding landscape. Where the operation is unlikely to adversely affect key species (due to ample surrounding habitat with sufficient connectivity or no threatened species), PNF could continue under a less restrictive code which does not increase the likelihood of poor silviculture. Where adverse impacts on key species are likely and prevention of these impacts requires modification of the forestry operations, financial incentives could be used to offset the commercial loss and encourage silvicultural treatment (Thompson and Connell 2006).

[6] Notably, Jay's (2006) analysis suggests that loss of habitat is not occurring in PNF anyhow, according to the evidence from general scoring systems.

[7] For example, through measurements taken across a range of private forest sites in Victoria, Vaughan et al. (2006) predicted the recovery of Habitat Hectare scores to 50% of their pre-harvest levels within the 10-year period required to demonstrate 'sustainability' under Victorian regulations, following clear-felling operations in Victorian forests.

A drawback to this approach is the likelihood of unsubstantiated ambit claims over species sensitivity from community groups opposed to native forest harvesting or silviculture. One solution is to use relatively impartial regional groups such as Catchment Management Authorities (CMAs) to document species of local significance and their critical habitat requirements. It would then be up to those paying biodiversity credits to reach a decision about relative species or habitat importance in private forests, rather than the 'everything is of equal importance' view which seems intractable for designing forest management systems allowing a mix of production and conservation. Natural resource management groups such as CMAs will need to understand that forests are dynamic and adaptive ecosystems and that particular species may be abundant at one time and less so at others. Populations may rise and fall with the vagaries of the seasons—outcomes that are outside the control of landowners and governments.

Perhaps a starting point for moving from a regulatory to a market-based system is information such as that generated by Kavanagh (2003), who investigated the sensitivity of various species to logging in similar NSW north coast eucalypt forests to those studied by Jay (2006). Kavanagh found that of 227 vertebrate species recorded across 487 forested sites, 40 (17.6%) were disadvantaged by logging, 40 (17.6%) appeared to be favoured by logging and 147 (64.8%) were unaffected. Those disadvantaged were dependent on large old trees with tree hollows, adding weight to the notion that specific habitat features can be important if protection of particular species rather than of general habitat structure is the objective.

Another argument for encouraging improved silviculture in private forests is to obtain the benefits provided by a vigorous and actively growing forest. These include improved nectar flows for fauna which are nectar feeders and increased carbon sequestration in actively growing relative to largely senescent forests. Polglase and Stein (2001) have stated that the net uptake of carbon dioxide by undisturbed old-growth forest is zero. In forests recovering from disturbance, including silvilcultural activities, carbon uptake is generally positive.

The Economic Benefits from PNF

Private native forestry in NSW has become a critical supply component for an industry sector which generates more employment per unit of area than agriculture, as illustrated in Table 4. In addition, private native forestry appears to generate environmental benefits in terms of habitat provision which exceed those of agricultural land uses such as cropping and grazing (Fig. 1). On these grounds, it could be argued that private native forestry is generating some unique 'public' benefits (employment and biodiversity) at a higher per hectare level than competing land uses and is therefore a land use worthy of encouragement through incentive mechanisms (just as CMAs in NSW use public funds to sponsor initiatives aimed at sustainable land use change).[8]

[8] Incentives from CMA are largely through the provision of public funding to facilitate private land-use changes which are deemed to generate environmental improvements both on and off the farm. These land-use changes may include a change of farming enterprise, a change in enterprise production methods, ceasing farming enterprises on some parts of the farm or managing part of the farm specifically for environmental outcomes.

Public Perception of Forestry

A fundamental obstacle to the payment of biodiversity credits for PNF is the public perception that forestry is environmentally damaging. This situation is exacerbated in NSW by the definition of land clearing which includes 'cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ringbarking, uprooting or burning native vegetation' (DIPNR 2004). This definition implies that PNF is synonymous with land clearing, an activity widely reported as *the* most significant threat to the Australian environment. The NSW definition is at odds with the Commonwealth definition, which states that 'Landclearing ... does not include silvicultural operations in native forests and manipulation of native vegetation composition and structure by grazing, burning or other means' (DEH 2005). The veracity of the Commonwealth definition is supported by ecological studies carried out during the Western Assessment Process showing forestry both as a separate activity to land clearing and ranking lower than several other threats in terms of disturbances to flora and fauna (Predavec 2002).

There seems to be a general community perception and acceptance that the best way to protect biodiversity in native vegetation is to fence the area off and exclude productive activity. While the studies of Jay (2006) and Predavec (2002) indicate that exclusion of production may not be necessary to enhance biodiversity, this form of biodiversity protection is widely practiced by publicly-funded natural resource management agencies (e.g. Bushcare[9]) and continues to be a major activity for CMAs in NSW to achieve biodiversity protection targets. Notably, there has been little assessment of the effectiveness of this approach in delivering real (quantified) gains in habitat management and improved biodiversity.

Unlike carbon credits where the product is quantified as a single numeric measure (tonnes of carbon removed from the atmosphere), the measurement of biodiversity value evokes considerable debate about general versus specific measures. Pannell (2004) noted that current definitions tend to be broad and non-specific. Freudenberger (2005) conceded that the scientific community is struggling to identify quantifiable attributes of biodiversity that could be utilised in a biodiversity credits trading system.

Pannell (2004) advocated that biodiversity needs to be quantified in terms of the higher-level benefits it provides to society such as a specific ecosystem service or a contribution to tourism, but conceded that, in practice, measuring the contribution of various biodiversity outcomes to these higher-level objectives is difficult. He suggested a fallback position might be to define narrower, more specific objectives that contribute to the higher level values, citing the net gain in native vegetation value as measured by the Habitat Hectares metric in Victoria as an example. However, as outlined above, it appears that a broad range of PNF management systems have little impact on scores such as Habitat Hectares and some ecologists regard such scores as too general in nature to provide any meaningful information on which to base habitat and biodiversity management decisions.

[9] Bushcare is an Australian Government funded program to conserve and restore habitat for Australia's native flora and fauna.

One factor in favour of PNF management systems as a form of biodiversity conservation was Pannell's (2004) finding that remnant native vegetation protection (from clearing) is likely to be the most cost-effective biodiversity protection measure in states where land clearing is still permitted.[10] In fact, land clearing in most Australian states is only permitted in limited circumstances, on a limited scale and often requires special permits or the re-planting of vegetation to replace any habitat removed. So-called 'broadscale land clearing' which permanently removes native vegetation is legally difficult to undertake in most Australian states. Jay (2006) and Vaughan et al. (2006) showed that general biodiversity values are protected under a range of private native forestry systems suggesting that sustainable private native forestry might be a more cost-effective measure than expensive revegetation schemes. The logic that vegetation conservation may be achieved at lower cost to revegetation was also highlighted by Possingham (2005).

Willingness to Pay for, and Willingness to Supply, Biodiversity Improvements

Economic techniques have been developed to place dollar values on biodiversity benefits. While the veracity of these techniques have been questioned (e.g. Pannell 2004), they provide an insight into the economic values society places on biodiversity conservation which is an indication of society's demand for this public good.

On the supply side of the ledger, there is a range of conservation schemes in place and surveys have been conducted which illustrate the size of the payments required for landholders to provide biodiversity conservation. A summary of values from several Australian studies is provided in Table 5.

For those values expressed in terms of dollars per hectare, there is a substantial difference between what the public is willing to pay for native vegetation conservation and what landholders require to supply this conservation.

For those values expressed in terms of willingness-to-pay (WTP) for species preservation, it is more difficult to assess if there is a large divergence between the demand and supply 'prices' because the number of hectares of vegetation (or kilometers of stream) required to deliver species protection is unclear. However, on the basis of the Victorian study showing an annual payment of $146 per household to protect 700 endangered species and NSW studies of landholder payments

[10] The land clearing regulations vary between Australian states, although no state has a total prohibition on land clearing with all states having various exemptions. In NSW, land clearing on private land is only permitted under particular circumstances, a permit is required and clearing not covered by the exemptions may necessitate the planting of 'offset' native vegetation to produce an equivalent habitat to that removed. PNF currently enjoys an exemption from this permit system in NSW, but changes to this process are imminent under the proposed PNF Code of Practice. In Victoria, clear-felling of some native forest communities (which equates to land clearing) is allowed under a permit system on the proviso that the forest regenerates to produce a particular level of habitat score after a specified period. In Western Australia, land clearing is permitted for specific purposes also under a permit system. In South Australia, there are some clearing exemptions for fence lines and firebreaks but broadscale clearing is prohibited. In Tasmania, clearing native vegetation for other land uses is capped, and by 2015 no clearing for this purpose will be permitted.

Table 5 Some willingness-to-pay and willingness-to-supply estimates for biodiversity conservation in Australia

Environmental attribute (proxy for improved biodiversity)	WTP (2005 $ Aus[a])	Payment type	Source
1 ha of improved remnant native vegetation management	0.00046	One-off per household	Lockwood and Carberry (1998)
1% increase in length of river with healthy native vegetation and wetlands in NSW	1.61–2.58[b] 2.24–2.90[c]	One-off per household	Bennett and Morrison (2001)
An additional fish species in a river	2.26–8.19[b] 2.26–6.99[c]	One-off per household	Bennett and Morrison (2001)
1% increase in number of waterbirds and other fauna species in a catchment	0.97–2.62[b] 0.97–2.00[c]	One-off per household	Bennett and Morrison (2001)
Additional endangered species in the Macquarie Marshes wetlands	5.01–5.16	One-off per household	Morrison et al. (1998)
Conservation of all 700 endangered species in Victoria	146	Annual payment	Jakobsson and Dragun (2001)
Conservation of Leadbeater's possum in Victoria	36	Annual payment	Jakobsson and Dragun (2001)
Reservation of 1% of remnant vegetation in the Fitzroy River Basin (Qld)	2.02 – 3.46	Annual payment	Windle (2003)
Remnant native vegetation conservation (fencing off) in the Namoi Catchment	Up to 120 $/ha	One-off payment to landholder from public funds	Namoi CMA (unpublished contribution rates)
Landholder contributions to remnant native vegetation conservation in he Namoi Catchment	12.33 $/ha	One-off contribution from landholder to supplement public funds	Namoi CMA (unpublished contribution rates)
Landholder payment required to fence off native bush on the Northern Tablelands of NSW	100–2,000 (mean 798) $/ha	One-off payment	Reeve et al. (2006)
Landholder payment required to fence off native bush on the Northern Tablelands of NSW	10–2,500 (mean 363) $/ha	Annual payment	Reeve et al. (2006)
Estimated landholder costs for excluding stock from native bush on the Northern Tablelands of NSW	117–167 $/ha	Includes initial fencing cost, annual stewardship cost and annual loss of production	Thompson (2006)

[a] Values for various years have been scaled by the Australian Consumer Price Index to 2005 values

[b] WTP estimates apply to the population within the catchment where the improvement will occur

[c] WTP estimates apply to a population outside the catchment where the improvement will occur

required to set aside areas of native vegetation (Reeve et al. 2006; Thompson 2006), it seems that there is some similarity of magnitude between willingness-to-pay and willingness-to-supply. Perhaps this reflects community willingness to pay more for well-defined outcomes (e.g. an actual number of species preserved) rather than for a more abstract environmental measure (e.g. area of remnant vegetation protected).

A substantial gap exists between what landholders say they require to fence off native vegetation and exclude livestock—an annual average payment of $363/ha based on responses from 52 New England wool producers (Reeve et al. 2006) and what whole-farm financial analysis suggests it would actually cost them - annually $117–167/ha according to Thompson (2006). Perhaps this reflects a landholder 'external scrutiny loading' for having government agencies involved in the management of their business.

It should also be noted that the results of willingness-to-supply surveys may not be a reliable indication of the actual price landholders are willing to accept. An auction process may more accurately reflect the opportunity cost of offering private land for conservation activity. Stoneham et al. (2002) found that a Victorian native vegetation conservation trial using an auction (BushTender) secured landholder involvement and biodiversity conservation at one seventh of the cost of a fixed price ($/ha) scheme. However, a study in the UK (Scottish Executive 2006) expressed skepticism at such findings and listed a number of features of the auction environment which need to be treated with caution. Heterogeneity of compliance costs and a large number of potential participants are listed as important pre-requisites for a successful auction process, and it is suggested this may be lacking in Scottish agriculture. However, given the paucity of information about the Australian PNF resource and the level of commercial use as highlighted by Prest (2003), together with the large number of farms which have native forests, auctions may prove to be a suitable mechanism for protecting key habitat attributes at least cost.

In the context of this paper, it should also be noted that total exclusion from productive uses is not necessarily an objective advocated by foresters or landholders, with these private forests remaining available for timber production and perhaps some limited grazing. A system could be devised with credits payable on the basis of sustainable forest management operations which protect general habitat features or protect the niches of species of key importance (for example large trees with hollows) or perhaps reward landholders for the presence of important flora and fauna species in their forests. Because commercial timber extraction is also allowed, this could reduce the opportunity cost and the WTP amount for landholders, and hence the total cost burden to governments.

Encouraging Better Silviculture in Private Native Forests

One obstacle to incentives for improved forest management is the belief of some conservation groups that if desired environmental outcomes cannot be achieved from PNF without a subsidy from the public purse, then the activity should not be allowed at all. However, this stance if pursued would eliminate virtually all natural

resource based production systems, including agriculture which attracts considerable public funding for conservation, environmental repair and research and development into environmentally friendly farming systems world-wide.

Jay (2006) observed that government log pricing arrangements and the lack of commercial uses for the timber generated during forest thinning operations often make high-grading the economically rational form of forest management. This is the reason why many forest stands on the North Coast of NSW are overstocked and dominated by non-commercial tree species. Modeling with EUCAMIX has demonstrated that silvicultural thinning on these stands does not generate a positive financial return if real discount rates greater than 3–5% are used.

Thompson (2006) reached a similar conclusion for eucalypt and cypress forests on the Northern Tablelands of NSW, where thinning costs in the order of $200/ha were not justifiable when timber royalties were in the order of just $10–25/m^3. Whole-farm modeling suggested that for the case-study farms examined, thinning was at best a marginal exercise and most financial improvement in thinned stands resulted from additional livestock carrying capacity rather than increased timber production. Likewise, Andrews (2003) reported thinning costs in cypress forests on the north–west slopes of NSW in the range $120–492/ha and a stumpage price (in 2001) of $18–30/m^3, and concluded that timber returns from thinning were low or negative for all but the most productive stands which could be thinned at low cost and attract high stumpage prices.

Jay (2006) also noted that the immediate negative cash-flow implications of thinning were a disincentive to better forest management, particularly when the benefits from improved timber production are not realised until 15–20 years into the future.

Economic circumstances suggest the following potential futures for the NSW PNF estate (and this is likely to be valid for Australian PNF in general):

1. In the absence of incentives for better silviculture, a continuation of the predominant form of activity, namely high-grading appears likely which will result in substantial reductions in commercial timber yields in one or two cutting cycles. This leaves the native timber industry, now heavily reliant upon private supplies, in a tenuous situation with the risk of further rationalisation, and the need to re-tool to handle smaller, lower quality logs or perhaps plantation timbers. Nolan et al. (2005) observed however that hardwood sawlog plantations are not coming on stream fast enough to replace dwindling native forest supplies.
2. A commercial solution to the current lack of PNF management is the development of markets for timber from thinning operations, to provide financial incentives for improved thinning management. Given the opposition of various high-profile conservation groups to native forest residues being used for biofuels and woodchip exports (e.g. WWF 2000), this option represents a considerable political challenge, despite the fact that native forest residues alone could meet 30% of Australia's Mandated Renewable Energy Target (Raison 2006).

3. Another commercial solution would involve an increase in the stumpage price for timber from private property, large enough to provide sufficient incentive to warrant investment in good silviculture. There is anecdotal evidence of stumpage prices increasing in some coastal areas of NSW with coastal sawmills now also seeking timber further inland (Northern Inland Forestry Investment Group 2005). There is also anecdotal evidence to indicate that most landholders do not know either the values or volumes of timber which are removed from their properties during logging operations by contractors, and under-payment is a common occurrence.
4. The solution to achieving improved management of PNF appears to lie with the explicit recognition of the off-farm values provided by well-managed native forests, and involves landholder recompense for those values in addition to or perhaps in place of timber income. This requires the development of an incentive payments system for private native forestry. It could include both payments for the preservation of key habitat attributes (e.g. tree hollows) and payments for the presence of important flora and fauna species in these forests. These could be combined with incentives for improved forest management (thinning, improved fire regimes) in those forests too degraded to warrant active landholder management on commercial (timber production) grounds.

Conclusions

The Australian private native forest estate is facing a number of conflicting and seemingly irreconcilable pressures, in NSW and other states. At the same time as PNF is becoming a critical component of industry sawlog supply, the resource is being degraded through poor silviculture.

Codes of Practice have been mooted for PNF, but foresters and economists predict the restrictions they impose will exacerbate high-grading thus violating the maintenance of future use requirements set out by the Ecologically Sustainable Development Working Group (1991). In contrast, conservation groups have asked for more stringent Codes of Practice in the pursuit of perceived increased habitat protection.

Economic conditions favour high-grading activity due to a combination of factors. These include poor past forestry practice which have produced a need for costly silvicultural intervention, low log prices (in part driven by state government price setting mechanisms), a lack of markets for low quality timber and forest residues, and a lack of landholder knowledge about the value of their forest resources or how to manage these for continuing sustainable timber production.

One avenue for improving private forest management may lie with incentives payments to preserve key habitat features and species viewed as important by society, while at the same time improving the financial capacity of landholders to undertake silvicultural operations. However, such an approach will require careful crafting to ensure both environmental and timber production goals are met within the bounds of an acceptable budgetary outlay.

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